DESCRIPTION

Compressor

TECHNICAL FIELD

The present invention relates to a compressor having an improved oil feeding means.

BACKGROUND ART

In recent years, responding to the requirement for global environment, energy saving movement in home use refrigerator is accelerated. Therefore, a coolant compressor is made to be an inverter type, and greater efforts are made to lower the rotation rate further. For such a low rotation rate compressor, by a centrifugal pump such as of prior art that was described in "National publication (in the Japanese) of translation of international patent application 2002-519589", it became difficult to obtain an ample oil feeding.

As for a compressor of prior art, in place of a conventional centrifugal pump, there is the one that is provided with a viscous pump by which a stable pumping capability is obtainable with less effort.

In the following discussion, referring to drawings, an explanation is given of the above-mentioned compressor of prior art.

Figure 7 is a cross-sectional drawing of a main part of the above-mentioned compressor of prior art. Referring to Figure 7, a hermetic container 1 stores oil 2 in its bottom part. An electric motor 5 is composed of a stator 6 having a coil, and a rotor 7 including a permanent magnet within it. On the outer periphery of a hollow shaft 11 provided in a compressor unit 10, sleeve 12 is fit and fixed so that it rotates integrally with the shaft 11. Further, on the outer periphery of the sleeve 12, the rotor 7 is inserted and fixed. And the bottom end of the sleeve 12 is immersed in the oil 2.

A bracket 15 formed in an approximately U-letter shape with a thread of piano wire is fixed at both its ends to a bottom plate 16 that is fixed to the rotor 7 of the motor 5. The sleeve 12 is made of plastic material, in which a rod 20 with a helical thread 20′ formed on its outer periphery is inserted in rotation-free manner. Between an outer peripheral surface of the rod 20 and an inner surface of the sleeve 12 facing to the outside of the rod 20 via a

narrow gap, an oil channel is formed. The bottom end of the rod 20 is fixed to the central part of the bracket 15 so that the rod 20 remains at rest within the sleeve 12 even when the sleeve 12 rotates together with the shaft 11 as a single unit.

The compressor of prior art constituted as described above operates as follows;

Upon electrifying the motor 5, its rotor 7 rotates. Therefore, the shaft 11 which is fit and fixed to the rotor 7 forming a single unit also rotates. By this rotation of the shaft 11, the compressor unit 10 performs its prescribed compressor action. And when the sleeve 12 rotates by the rotation action of the shaft 11, the inner wall of the sleeve 12 becomes to rotate with respect to the outer wall of the rod 20. As a result, oil 2 receives a rotating force and is dragged by the viscosity existing in the relative rotation between the sleeve 12 and the rod 20 within the oil channel formed between the helical thread 20' formed on the outer periphery of the rod 20 and the inner wall of the sleeve 12. That is, due to the relative rotation of the sleeve 12, oil layer contacting its inner surface provides a rotating force due to the viscosity to oil layer on the rod surface as well as in the above-

mentioned helical thread 20', then this rotating force drags the oil in the channel along the helix so as to let it be rotated and moved upward. The oil moved upward inside the sleeve 12 is pumped up toward the upper hollow part of the shaft 11 via a horizontal hole in the shaft 11 and through the vertical hole in the center shaft part of the shaft 11. This upward movement of the oil 2 toward the upper hollow part of the shaft 11 is not caused by the centrifugal force, but it is due to the action of rotating upward movement by a force dragged by the viscosity, thereby a stable oil pumping-up at a low rotating rate at which the centrifugal force is small can be achieved.

SUMMARY OF INVENTION

However, in the configuration of the above-mentioned example of the prior art, the structure is such that the bracket 15 made of wire holds and fixes the rod 20. Therefore, when the dimensional accuracy of the bracket 15 is low, good coaxial relationship between the outer wall of the rod 20 and the wall of the sleeve 12 is not maintained, the rod 20 is forced on some parts of the inner wall somewhere of the sleeve 12 and causes undesirable contact on the sleeve 12. In

order to absorb the occurrence of a large frictional force due to this contact, the bracket 15 is designed to be formed of elastic material. When the contact force is large, however, an extraordinary abrasion takes place between the sleeve 12 and the rod 20, and the pump capability declines, or abrasion particles are produced, which are circulating over the sliding-motion part together with oil and entering into the sliding-motion part, spoiling the operation of the compressor unit seriously and moreover there was a shortcoming that is even to lock the compressor unit.

Also, the rod 20 requires a mold, which necessitates a complicated process in its manufacturing period to form a helical groove on its whole outer peripheral surface, and hence there was a shortcoming that causes the rise of cost of the compressor.

The present invention purposes to provide a compressor that is highly reliable and does not require any marked high cost in its manufacturing.

To solve the above-mentioned problem of the prior art, an oil pump of a compressor of the present invention is provided with a helical groove engraved helically on the outer periphery of the above-mentioned shaft and an approximately cup shaped sleeve that is

associated loosely to the outer periphery of the above-mentioned shaft. The bottom part of the above-mentioned shaft and bottom face of the above-mentioned sleeve are coupled freely in their rotation, and a rotation suppression means for suppressing the rotation of the above-mentioned sleeve is provided. By the rotation-suppressed sleeve, relative rotation difference with respect to the helical groove is produced. Then, associated with the rotation of the shaft, oil being contacting the inner periphery of the sleeve is dragged due to its viscosity. Thus, the oil is rotated and raised and thereby oil-feeding is accomplished. As a result, an effective viscosity pump can be formed with a small number of parts. Since the bottom part of the shaft and bottom face of the above-mentioned sleeve are coupled freely in their rotation, the relative position of the shaft and the sleeve is restricted, resulting in reducing a chance of occurrence of twisting action between the sleeve and the shaft.

According to the compressor unit of the present invention, the technical effect is obtained such that a compressor having a high mechanical reliability can be offered.

According to a first aspect of the present

invention, a compressor can be offered, wherein in a hermetic container containing oil therein, an electric motor including a stator and a rotor contained in the above-mentioned hermetic container, and a compressor unit which is driven by the above-mentioned electric motor, are provided; and the above-mentioned compressor unit comprises shafts expanding in the vertical direction and making the rotating motion and an oil pump which is formed at the lower end of the above-mentioned shaft and connected to the above-mentioned oil; the above-mentioned oil pump includes a helical groove provided helically on the outer periphery of the above-mentioned shaft and a cup-shaped sleeve that is loosely coupled on the outer peripheral end part of the above-mentioned shaft so that it covers the lower end of the above-mentioned helical groove and is coupled in rotation-free manner to the bottom part of the above-mentioned shaft, and the rotation-suppression means for suppressing the rotation of the above-mentioned sleeve.

According to a second aspect of the present invention, a technical effect through which a compressor in accordance with the above-mentioned feature can be offered, wherein the above-mentioned rotation suppression means is the bracket which is held

between the above-mentioned stator and the above-mentioned sleeve and fixes the above-mentioned sleeve to the above-mentioned stator.

According to a third aspect of the present invention, a technical effect through which a compressor in accordance with the above-mentioned feature can be offered, wherein the above-mentioned rotation suppression means is a wing part which is formed on the outer periphery of the above-mentioned sleeve and generates the viscous resistance with respect to the oil.

According to a fourth aspect of the present invention, a technical effect through which a compressor in accordance with the above-mentioned feature can be offered, wherein the above-mentioned rotation suppression means is permanent magnets and a member which acts magnetically to them fixed directly or indirectly to both of the above-mentioned sleeve and the above-mentioned hermetic container.

According to a fifth aspect of the present invention, a technical effect through which a compressor in accordance with either one of the above-mentioned features can be offered, wherein the above-mentioned shaft has, on its shaft center, an oil hole

expanding in the vertical direction which is connected to the sliding-motion part between the shaft and a member accepting and allowing the sliding-rotation motion of the shaft within it, and the upper end of said helical groove is connected to said oil hole expanding in the vertical direction.

According to a sixth aspect of the present invention, a technical effect through which a compressor in accordance with either one of the above-mentioned features can be offered, wherein the above-mentioned sleeve is formed by integral molding of the synthetic resin.

According to a seventh aspect of the present invention, a technical effect through which a compressor in accordance with either one of the above-mentioned features can be offered, wherein the above-mentioned compressor unit is supported elastically in the above-mentioned hermetic container.

According to an eighth aspect of the present invention, a technical effect through which a compressor in accordance with either one of the above-mentioned features can be offered, wherein the above-mentioned electric motor unit is driven by operation frequencies including frequencies less than the power

source frequency.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a vertical cross-sectional drawing of a compressor according to Example 1 of the present invention.

Figure 2 is a vertical cross-sectional drawing of a part of the compressor according to Example 1 of the present invention.

Figure 3 is a vertical cross-sectional drawing of a compressor according to Example 2 of the present invention.

Figure 4 is a vertical cross-sectional drawing of a part of the compressor according to Example 2 of the present invention.

Figure 5 is a vertical cross-sectional drawing of a compressor according to Example 3 of the present invention.

Figure 6 is a vertical cross-sectional drawing of a part of the compressor according to Example 3 of the present invention.

Figure 7 is a vertical cross-sectional drawing of a part of a compressor of prior art.

DETAILED DESCRIPTION OF THE INVENTION

In the following, explanation is given on preferable examples of the compressor in accordance with the present invention, referring to the drawings.

<< Example 1 >>

Figure 1 is a cross-sectional drawing of a compressor unit according to Example 1 of the present invention, Figure 2 is a main part cross-sectional drawing of the main part of according to the same Example 1.

In Figure 1 and Figure 2, a hermetic container 101 stores lubrication oil 102, and at the same time it is charged up with coolant gas 103. Hereupon preferably the coolant gas 103 is R600a, which is hydrocarbon coolant, and the oil 102 is preferably synthetic oil. Also, mineral oil, or polyol ether oil, which are those having compatibility with the above-mentioned coolant gas 103.

A compressor unit 110 is provided with a block 115 having a cylinder 113, a piston 117 inserted into the cylinder 113 so as to make reciprocating motion therewith, a shaft 125 consisting of a main shaft part 120 supported by a bearing section 116 of the block 115

and an eccentric part 122, and a connecting rod 119 connecting the eccentric section 122 and a piston 117, thereby building a reciprocal type compressor unit.

Electric motor 135 comprises a stator 136, which is connected to an inverter drive circuit (not shown) fixed underneath the block 115 and the rotor 137, which includes a permanent magnet within it and is fixed to the main shaft part 120. This electric motor unit is driven by the inverter drive circuit (not shown) at various operation frequencies including operation frequencies below 20 Hz.

Spring 139 is engaged at its lower end to the bottom of the hermetic container 101, and by its upper end supports the stator 136 and the compressor unit 110 which is composed integrally with the stator; and thus the spring supports the compressor unit 110 elastically with regard to and over the bottom part of the sealed container 101.

At the lower end of the main shaft part 120 of the shaft 125, an oil pump 140 immersed in oil 102 is provided.

In the following discussion, referring particularly to Figure 2, a detailed description is given of the configuration of the oil pump 140 which is

the feature of the present invention.

On the periphery of the lower part of the main shaft part 120, a lower part helical groove 142 is provided. Also, an upper part helical groove 142′ is provided on the upper part of the main shaft periphery. In this main shaft part 120, there is a vertical hole 144, which is concentric with respect to its center axis.

To the vertical hole 144, oil holes namely a lower part horizontal hole 144′ and an upper part horizontal hole 144″, which are respectively connected to their respective outer faces of the main shaft part 120 at their respective slide-motion parts which slide on a lower sleeve 146 and its upper locating bearing 116, respectively, are provided in the main shaft part 120. The lower part horizontal hole 144′ connects the upper end of the lower part helical groove 142 to the vertical hole 144; and the upper part horizontal hole 144″ connects an upper end part of the vertical hole 144 which is along with the central axial part of the shaft 120 to the lower end part of the upper part helical groove 142′.

An approximately cup-shaped sleeve 146, which has a depth capable of accommodating the lower part

helical groove 142, is made of synthetic resin (desirably, integral-molded article of PBT polybutylene terephthalate) having the coolant resistant and oil-resistant property. The so-called approximately cup-shaped sleeve includes variants such as a cylindrical shape and a circular truncated cone shape, and besides the above, a cup shape having a side surface of the second-order may be usable. The sleeve 146 has a bolt fastening hole 150 (Fig. 2) provided on the bottom face, and an oil-intake 152 provided on the side surface, and the skirt part 154 protruded downward from the bottom plate. Hereupon, in another example, an oil intake 152 may be provided on the bottom plate. Then, the gap between the inner diameter of the sleeve 146 and the lower part peripheral diameter of the main shaft 120 is selected to be from 100 µm to 500 µm in their diameters.

At the bottom end of the main shaft part 120, the bolt 160 is screw-fixed to the threaded bottom end part of the vertical hole 144 through the bolt fastening hole 150 provided on the bottom plate 146’ with a washer 162 inserted therebetween. The bolt fastening hole 150 of the bottom plate 146’ is made to be larger than the outer diameter of the screw part of the bolt 160, and the head of the bolt 160 is loosely

fixed to the bottom plate of the sleeve 146. By this loose fixing composition, the main shaft 120 attached with the bolt 160 is engaged to the sleeve 146 freely in its rotation. The bolt 160 seals the bottom end of the vertical hole 144. The washer 162 is formed of high abrasion resistant material (preferably, such as tetrafluoroethylene having the self-lubrication property), thereby enabling smooth rotation of the sleeve 146 with respect to the main shaft part.

Brackett 170, which is preferably formed in an approximately trapezoidal shape with a spring steel wire of iron material and is fixed to the stator 136 at both ends, engages with a skirt part 154 expanding below the sleeve 146. Thereby the bracket holds the sleeve 146 such that the sleeve 146 does not rotate around its center axis.

On the compressor of examples constituted as has been described above, the operation is elucidated hereinafter.

The rotor 137, hence the shaft 125, and the main shaft part 120 rotate when the stator 136 is turned on from the inverter driving circuit. Accompanying with the above, the eccentric motion of the eccentric part 122 forces the piston 117 to make

the reciprocating motion in the cylinder 113 through the connecting rod 119. Therefore, the piston 117 performs so-called compression action that compresses the intake gas inside of the cylinder.

Accompanying with the rotation of the shaft 125, the main shaft part 120 rotates, and then the lower part helical groove 142 rotates in the sleeve 146, which is supported by the bracket 170 so as not to rotate. Accordingly, a frictional resistive force due to the viscous resistance with respect to the sleeve 146 is caused in the oil 102 in the lower part helical groove 142. By this frictional resistive force, the oil 102 rotates in the rotating direction of the sleeve 146 seen relatively from the lower part helical groove 142. By this relative rotation with respect to the lower part helical groove 142, a certain amount of oil pressure takes place, and by this pressure the oil 102 rises up in the lower part helical groove 142. With this rise-up of the oil 102, an oil pressure takes place in the oil 102 in the lower part helical groove 142. Due to this, oil 102 rises up in the vertical hole 144. The oil 102 which rises up in this manner is reaching the slide-moving part formed by the inner peripheral surface of the bearing 116 and the outer

peripheral surface of the main shaft part 120, and lubricates the slide-moving part.

In the present example, coolant gas 103 is preferably a hydrocarbon type coolant, 600a, and for oil 102, synthetic oil, petrolatum, or polyol ester oil. All of them having the compatibility with the coolant gas 103, is used. As for this hydrocarbon type coolant, its molecular weight is small because it contains no chlorine nor fluorine, and in particular, it has a high compatibility with synthetic oil or petrolatum. As a result, an extreme declination in oil viscosity may be induced. In general, when the oil viscosity declines, the viscous resistance falls, likely bringing about disadvantages in the lubrication. However, in the present example, since it does not depend much upon the centrifugal force, which decreases at low rotation rates, the oil is raised up by a viscosity force that drags oil due to its viscosity. Therefore, it is confirmed that a stable pumping-up of the lubricant oil is realized even at low rotation rates such as 600 rpm.

If the gap in the direction of the diameter between the inner diameter of the sleeve 146 and the lower part outer periphery of the main shaft 120 is too large, oil drops therebetween and the amount of

lubrication decreases. However, it is experimentally confirmed that there is no such large amount of decrease of oil feeding when the gap is selected to a gap from 100 μm to 500 μm in diameter, and moreover that any inconvenient contact between the inner wall of sleeve 146 and the lower part outer periphery of the main shaft 120 hardly occurs.

In accordance with the present example, the sleeve 146 is short in its length and it is coupled with the bolt 160 in rotatable relation to the lower end of the main shaft part 120 of the shaft 125 with a washer 162 therebetween. Therefore, as for the relative positional relationship of the sleeve 146 with respect to the main shaft part 120, an approximately constant clearance is kept between them in the direction of their diameter. Thereby, the lateral pressure due to inclination between them and also due to a difference in their axial positions hardly occurs. And, owing to the oil pressure created in the upper and lower part helical grooves 142′ and 142, the gap between the main shaft part 120 and the sleeve 146 as well as each gap on the main shaft is maintained at a good condition. In this way, the sliding abrasion between the sleeve 146 and the main shaft part 120 becomes very little.

As a result, owing to the decrease of the sliding abrasion between the main shaft part 120 and the sleeve 146, any such trouble which may have occurred in the prior art is eliminated or decreased, such that abrasion particles produced from the rod provided at the shaft lower part circulates together with the oil flow through the sliding part of the compressor, and the abrasion particles thus produced and circulating are bit into the sliding part and make the compressor unit being locked. Therefore, in the present example in which the present invention is implemented, a compressor having a high reliability could be realized.

Also, as for the main shaft part 120, because the upper part and the lower part helical grooves 142′ and 142 are provided directly on two parts of the outer periphery, they can be formed easily by, such as, end mill if processing is carried out while turning the main shaft part 120, resulting in making the manufacturing automation easy.

Furthermore, as for the approximately cup-shaped sleeve 146, since it has a simple shape as it can be made in an integral molding article of PBT, any complex shaped mold is not necessary and it can be

manufactured at low cost. Therefore, it becomes possible to be equipped with a high viscous pump having high productivity, resulting in making it possible to provide a low cost compressor.

<< Example 2 >>

Figure 3 is a sectional view in the vertical section of a compressor according to Example 2 of the present invention, and Figure 4 is a sectional view of expanded principal part of the lower part according to the same example

Hereinafter, referring to Figure 3 and Figure 4, an explanation is given of the example of the present invention. For those parts of the same or considerably the same composition with those of Example 1, identical numerals are given and detailed explanation is omitted.

In the sleeve 246 that is installed to the lower end of the main shaft part 120 of the shaft 125 constituting a compressor unit 210, an oil pump 240 that is immersed in the oil 102 is formed.

In the following discussion, a detailed explanation is given of the configuration of an oil pump 240.

On the periphery of the lower part of the main shaft part 120, a lower part helical groove 142 is provided. It is similar to the Example 1 shown in Figure 2. A vertical hole 144 is provided inside the main shaft part 120 along its axial center (as shown in Figure 4). The vertical hole 144 is connected to the sliding part, which is formed by the main shaft part 120 and the bearing 116. The upper end of the lower part helical groove 142 is connected to the vertical hole 144 through the horizontal connecting hole 144'.

And, the approximately cup-shaped sleeve 246, which has a depth capable of accommodating the lower part helical groove 142, is made as an integral-molded article with synthetic resin (desirably PBT) having the coolant resistant and oil-resistant property. The word of approximately cup-shaped sleeve means that it can include various variants as in the Example 1. The sleeve 246 has a bolt fastening hole 250 provided on the bottom plate 246', and an oil intake 252 provided on the side surface, and also has a plural number of wings 256 that are formed protruding outward to the outer peripheral direction. Hereupon, the oil intake 252 can be provided on the bottom plate. Then, the gap between the inner diameter of the sleeve 246 and the

lower part peripheral diameter in the main shaft part 120 is selected to be from 100 μm to 500 μm in their diameters.

At the bottom end of the main shaft part 120, the bolt 160 is screw-fixed to the threaded bottom end part of the vertical hole 144 through the bolt fastening hole 250 provided on a bottom plate 246′ locating near the lower end of a sleeve 246 with inserting a washer 162 therebetween. The bolt fastening hole 250 of the bottom plate 246′ is made to be larger from the outer diameter of the screw part of the bolt 160, and the head of the bolt 160 is loosely fixed to the bottom plate of the sleeve 246. By this configuration, the main shaft part 120 attached with the bolt 160 is engaged to the sleeve 246 freely in its rotation. The bolt 160 seals the bottom end of the vertical hole 144. The washer 162 is formed of high abrasion resistant material (preferably, such as tetrafluoroethylene having the self-lubrication property), thereby enabling smooth rotation of the sleeve 246 with respect to the main shaft part 120.

On the compressor of the Example 2 constructed as described above, its operation is described hereinafter.

The rotor 137, hence the shaft 125, and the main shaft part 120 rotate and the lower part helical groove 142 rotates in the sleeve 246 when the stator 136 is turned on from the inverter drive circuit. Although the sleeve 246 is to rotate by being dragged by the rotation of the main shaft part 120, because of strong viscous resistivity caused by the rotation of the wings 256 in oil 102, the sleeve 246 rotates at a low rotation rate which is far below from the rotation rate of the main shaft 120. Therefore, between the main shaft part 120 and the sleeve 246, a rotation rate difference that is close to the rotation rate of the shaft 125 takes place.

According to the above-mentioned action, in the oil 102 in the helical groove, a frictional resistive force due to the viscous resistance with respect to the sleeve 146 is caused. By this frictional resistive force, the oil 102 rotates in the rotating direction of the sleeve 246 seen relatively from the lower part helical groove 142, and by this relative rotation with respect to the helical groove, a certain amount of oil pressure takes place and by this oil pressure the oil 102 rises up in the lower part helical groove hole 142. With this rise-up of oil, an oil

pressure takes place in the oil 102 in the helical groove, and due to this, oil rises up in the vertical hole 144. The oil thus rising up is reaching the sliding-motion part formed by the inner peripheral surface of the bearing 116 and the outer peripheral surface of the main shaft part 120, then lubricating it.

In the present example, coolant gas 103 is preferably a hydrocarbon type coolant, 600a, and for the oil 102, synthetic oil, petrolatum, or polyol ester oil. All of them having the compatibility with the coolant gas 103, is used. As for this hydrocarbon type coolant, its molecular weight is small because it contains no chlorine nor fluorine, and in particular, it has a high compatibility with synthetic oil or petrolatum. As a result, an extreme declination in oil viscosity may be induced. In general, when the oil viscosity declines, the viscous resistance falls, likely bringing about disadvantages in the lubrication. However, in the present example, since it does not depend much upon the centrifugal force, which decreases at low rotation rates, but the oil 102 is raised up by a viscosity that drags oil due to its viscosity. Therefore, it is confirmed that a stable pumping-up of the lubricant oil is realized even at low rotation

rates such as 600 rpm.

If the gap in the direction of the diameter between the inner diameter of the sleeve 246 and the lower part outer periphery of the main shaft part 120 is too large, oil drops therebetween and the amount of lubrication decreases. However, it is experimentally confirmed that there is no such large amount of decrease of oil feeding if the gap is a gap from 100 μm to 500 μm in diameter, and moreover that any inconvenient contact between the inner wall of sleeve 246 and the lower part outer periphery of the main shaft part 120 hardly occurs.

In the present example, the sleeve 246 is coupled to the bolt 160 freely in its rotation with letting a washer 162 be present at the lower end of the main shaft part 120. And the bolt fastening hole 250 of the bottom plate 246′ is made to be larger from the outer diameter of the screw part of the bolt 160, and the head of the bolt 160 is loosely fixed to the bottom plate 246′ of the sleeve 246. By this configuration, the main shaft part 120 attached with the bolt 160 is engaged to the sleeve 246 freely in its rotation and the relative position between them is determined by the relative relation between the head of the bolt 160 and

the main shaft 120 above-mentioned above. The bolt 160 seals the bottom end of the vertical hole 144. The washer 162 is formed of high abrasion resistant material (preferably, such as tetrafluoroethylene having the self-lubrication property), thereby enabling smooth rotation of the sleeve 246 with respect to the main shaft part 120. Owing to the action of oil pressure produced in the lower part helical groove 142, the gap between the sleeve 246 and the main shaft part 120 is maintained constant. Therefore, contact or lateral pressure possibly occurring between the sleeve 246 and the main shaft part 120 due to the difference in their axial positions does not take place, and hence the occurrence of the sliding abrasion between them becomes very little.

Since the sliding-motion friction is small, such the phenomenon disappeared that the abrasion particles were produced and they circulated in the sliding-motion part with oil, and they were bit into the sliding-motion part and made lock the compressor. Therefore, a compressor having a high reliability could be realized.

Also, since the lower part helical groove 142 provided on a part of the lower outer periphery of the

main shaft part 120 is carved directly on the main shaft part made of metal, it can be formed by, such as, end mill when processing is carried while turning the main shaft part 120, resulting in making the manufacturing automation easy.

Furthermore, the sleeve 246 can be formed together with the wings 256 with such as PBT by integration molding, and since it has a simple shape, no complex-shaped mold is necessary, thereby making a low cost manufacturing possible.

Since the wings 256 receives, in the oil 102, a strong viscous resistance in the rotation direction, its own rotation is disturbed, it is not necessary to fix the sleeve 246 indirectly to the stator, hence the configuration becomes very simple that it is only required to couple it to the main shaft part 120 by the bolt 160, requiring only a limited number of parts and manufacturing steps. Therefore, it becomes possible to equip a viscous pump having high productivity, thereby a low-cost compressor can be offered.

<< Example 3 >>

Figure 5 is a vertical cross-sectional drawing of a compressor cut along the vertical section

according to Example 3 of the present invention, and Figure 6 is an expanded cross-sectional drawing of lower main part of the compressor according to the same example mode of the present invention

In the following discussion, referring to Figure 5 and Figure 6, an explanation is given of the present example. For those parts of the same or considerably the same composition with those of Example 1, identical numerals are given and detailed explanation is omitted.

In the sleeve 346 that is installed to the lower end of the main shaft part 120 of the shaft 125 constituting a compressor unit 210, an oil pump 240 immersed in the oil 102 is formed.

In the following discussion, a detailed explanation is given of the composition of an oil pump 240. On the periphery of the lower part of the main shaft part 120, a lower part helical groove 142 is provided. It is similar to the Example 1 which is shown in Figure 2. A vertical hole 144 is provided inside the main shaft part 120 along its axial center (as shown in Figure 6). The vertical hole 144 is connected to the sliding part which is formed by the main shaft part 120 and the bearing 116. The upper end of the lower part

helical groove 142 is connected to the vertical hole 144 through the horizontal connecting hole 142′.

An approximately cup-shaped sleeve 346, which has a depth capable of accommodating the lower part helical groove 142, is made by integral-molded article with synthetic resin (desirably PBT) having the coolant resistant and oil-resistant property. The word of approximately cup-shaped sleeve means that it can include various variants as in the Example 1. The sleeve 346 has a bolt fastening hole 350 provided on the bottom plate 346′, and an oil intake 352 provided on the side surface, and also has a plural number of arms 356 that are formed protruding outward to the outer peripheral direction. Hereupon, in another example, an oil intake 352 can be provided on the bottom plate 346′.

The gap between the inner diameter of the sleeve 346 and the lower part peripheral diameter in the main shaft part 120 is selected from 100 μm to 500 μm.

On the arms 356, rotating permanent magnets 358 are fixed respectively and the stationary permanent magnets 360 placed at positions approximately facing to the permanent magnets 358 are provided on the inner

bottom surface of the hermetic container 101 with suitable predetermined gaps through which mutual magnetic force with respective permanent magnets 358 can act. A plural number of arms 356, permanent magnets 358, and stationary permanent magnets 360 constitute a rotation suppression means. Hereupon, the permanent magnets 358 and the stationary permanent magnets 360 are provided in a manner that their mutually facing faces become opposite poles, respectively.

At the bottom end of the main shaft part 120, the bolt 160 is screw-fixed to the threaded bottom end of the vertical hole 144 through a bolt fastening hole 350 provided on the bottom plate 346′ locating near the lower end of a sleeve 346 with a washer 162 instead therebetween. The bolt fastening hole 350 of the bottom plate 346′ is made to be larger from the outer diameter of the screw part of the bolt 160, and the head of the bolt 160 is loosely fixed to the bottom plate 346′ of the sleeve 346′. By this configuration, the main shaft 120 attached with the bolt 160 is engaged to the sleeve 346 freely in its rotation. And the bolt 160 seals the bottom end of the vertical hole 144. The washer 162 is formed of high abrasion resistant material (preferably, such as tetrafluoroethylene having the self-lubrication

property), thereby enabling smooth rotation of the sleeve 346 with respect to the main shaft part 120.

On the compressor of the Example 3 constructed as described above, its operation is described hereinafter.

The rotor 137, therefore the shaft 125, and the main shaft part 120 rotate and the lower part helical groove 142 rotates in the sleeve 346 when the stator 136 is turned on from the inverter drive circuit. Although the sleeve 346 is to rotate by being dragged by the rotation of the main shaft part 120, since permanent magnets 358 to which the arms are fixed and stationary permanent magnets 360 fixed on the bottom inner plane of the hermetic container 101 attracts to each other, free rotation of the sleeve 346 with respect to the main shaft 120 is prevented. As a result, a difference between their rotation rates takes place.

According to the above action, in the oil 102 in the lower part helical groove 142, a frictional resistive force due to the viscous resistance with respect to the sleeve 346 is caused. By this frictional resistive force, the oil 102 rotates in the rotating direction of the sleeve 346 seen relatively from the lower part helical groove 142, and by this relative

rotation with respect to the lower part helical groove 142, a certain amount of oil pressure takes place and by this oil pressure the oil rises up in the lower part helical groove 142. With this rise-up of oil, an oil pressure takes place in the oil in the lower part helical groove 142, and due to this, the oil 102 rises up in the vertical hole 144. The oil thus rising up reaches the slide-motion part formed by the inner peripheral surface of the bearing 116 and the outer peripheral surface of the main shaft part 120, and lubricates it.

In the present example, coolant gas 103 is a preferably hydrocarbon type coolant, 600a, and for the oil 102, synthetic oil, petrolatum, or polyol ester oil. All of them having the compatibility with the coolant gas 103 is used. As for the hydrocarbon type coolant, its molecular weight is small because it contains neither chlorine nor fluorine, and in particular, it has a high compatibility with synthetic oil or petrolatum. As the result, there may be induced an extreme declination in oil viscosity. In general, when the oil viscosity declines, the viscous resistance falls, likely bringing about disadvantages in the lubrication. However, in the present example, since it

does not depend much upon the centrifugal force, which decreases at low rotation rates, but the oil 102 is raised up by a force that drags oil due to its viscosity. Therefore, it is confirmed that a stable pumping-up of the lubricant oil is realized even at low rotation rates such as 600 rpm.

If the gap in the direction of the diameter between the inner diameter of the sleeve 346 and the lower part outer periphery of the main shaft 120 is too large, oil 102 drops therebetween and the amount of lubrication decreases. However, it is experimentally confirmed that there is no such large amount of decreasing of oil feeding if the gap is a gap from 100 μm to 500 μm in diameter, and moreover that any inconvenient contact between the inner wall of sleeve 346 and the lower part outer periphery of the main shaft 120 hardly occurs.

In the present example, the sleeve 346 is coupled to the bolt 160 freely in its rotation with letting the washer 162 be present at the lower end of the main shaft part 120. And the bolt fastening hole 350 of the bottom plate 346′ is made to be larger from the outer diameter of the screw part of the bolt 160, and the head of the bolt 160 is loosely fixed to the

bottom plate 346′ of the sleeve 346. By this configuration, the main shaft part 120 attached with the bolt 160 is engaged to the sleeve 346 freely in its rotation and the relative position between them is determined by the relative relation between the head of the bolt 160 and the main shaft 120 mentioned above. The bolt 160 seals the bottom end of the vertical hole 144. The washer 162 is formed of high abrasion resistant material (preferably, such as tetrafluoroethylene having the self-lubrication property), thereby enabling smooth rotation of the sleeve 346 with respect to the main shaft part 120. Owing to the action of oil pressure produced in the lower part helical groove 142, the gap between the sleeve 346 and the main shaft part 120 is maintained constant. Therefore, contact or lateral pressure possibly occurring between the sleeve 346 and the main shaft part 120 due to the difference in their axial positions does not take place, and hence the occurrence of the sliding abrasion between them becomes very little.

Since the sliding-motion friction is small, such the phenomenon disappeared that the abrasion particles were produced and they circulated in the

sliding-motion part with oil, and they were bit into the sliding-motion part and made lock the compressor. Therefore, a compressor having a high reliability could be realized.

Also, since the lower part helical groove 142 provided on a part of the lower outer periphery of the main shaft part 120 is carved directly on the main shaft part made of metal, it can be formed by a standard machinery such as end mill by processing while turning the main shaft part 120, resulting in making the production automation easy.

The sleeve 346 can be formed together with the arms 356 preferably with PBT by integration molding, and since it has a simple shape, any complex shaped mold is not necessary, making a low cost production possible.

Furthermore, respective permanent magnets 358 are fixed on the arms 356, and due to the mechanism that the stationary permanent magnets 360, which are placed at positions approximately facing to the permanent magnets 358, are provided on the inner bottom surface of the hermetic container 101 with a suitable predetermined gap, the rotation is disturbed, then it becomes unnecessary to fix the sleeve 346 indirectly to

the stator 136, and an extremely simple configuration of only connecting it to the main shaft part 120 with a bolt 160 can be employed, requiring only a limited number of parts and manufacturing steps. Therefore, it is possible to offer a low-cost compressor equipped with a viscous pump having high productivity.

Hereupon, in the above-mentioned examples, the one using the attracting force of the permanent magnet has been described as the form of the present implementation. Besides, a configuration wherein arranging the same poles of permanent magnets, so that they are facing to each other and in the direction of the rotation of the shaft and thereby gaining the repulsive force of the permanent magnet, with this repulsive force the rotation of the sleeve being obstructed. Furthermore, the same or similar function can be gained also with using soft iron or soft ferrite for the one side of the magnets which are provided on the arms or on the bottom plate of the hermetic container.

INDUSTRIAL APPLICABILITY

The compressor in accordance with the present invention can be used for those apparatuses using the

freezing cycle such as home-use refrigerators, dehumidifiers, food showcases, or vending machines.